La Moine/Missouri Creek Watershed Total Maximum Daily Load and Load Reduction Strategies

Stage 1 Report – Public Review Draft

1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Report Prepared by:

TETRA TECH

July 2016

Contents

Figures

Tables

Acronyms and Abbreviations

AFOs	animal feeding operations
AUID	Assessment Unit ID
AWQMN	Ambient Water Quality Monitoring Network
CAFO	confined animal feeding operation
CFR	Code of Federal Regulation
CFU	colony forming unit
CV	coefficient of variation
CWA	Clean Water Act
HSG	hydrologic soil group
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
LA	load allocation
LRS	load reduction strategy
MGD	millions of gallons per day
MHP	mobile home park
MOS	margin of safety
N/A	not applicable
NPDES	National Pollutant Discharge Elimination System
STEPL	Spreadsheet Tool for the Estimation of Pollutant Load
STP	sewage treatment plant
TMDL	total maximum daily load
TP	total phosphorus
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	wasteload allocation
WQS	water quality standards
WWTP	wastewater treatment plant

1. Introduction

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting those standards. In addition to TMDL development, Illinois EPA also develops load reduction strategies (LRS) which address pollutants in the watershed that do not have water quality standards, namely nutrients and sediment in streams. This TMDL and LRS study addresses the approximately 851 square mile La Moine/Missouri Creek watershed located in west central Illinois. The headwaters for the La Moine River begins in the Upper La Moine watershed and waters within this portion of the watershed are being addressed in a separate TMDL and LRS study. Several waters within the La Moine/Missouri Creek project area have been placed on the State of Illinois 303(d) list, and require the development of a TMDL. There are no waters that require a LRS.

1.1 TMDL Development Process

The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA 1991).

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for regulated sources and load allocations (LAs) for unregulated sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The Illinois EPA will be working with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

1.2 Water Quality Impairments

Several waters within the La Moine/Missouri Creek watershed have been placed on the State of Illinois §303(d) list (Table 1and Figure 1), and require development of TMDLs. TMDL project is intended to address documented water quality problems in the La Moine/Missouri Creek watershed.

Figure 1. La Moine/Missouri Creek watershed.

Table 1. La Moine/Missouri Creek watershed impairments and pollutants (2014 Illinois 303(d) Draft List)

Name	Segment AUID	Segment Length (Miles)	Watershed Area (Sq. Miles)	Designated Uses	TMDL Parameters
La Moine River	IL_DG-01	22.61	851	Primary contact recreation	Fecal coliform
La Moine River	IL_DG-04	11.38	396	Primary contact recreation	Fecal coliform
Missouri Creek	IL_DGD-01	27.55	742	Aquatic life	Manganese
Little Missouri Creek	IL_DGDA-01	15	37	Aquatic life	Dissolved oxygen, manganese

2. Watershed Characterization

The La Moine/Missouri Creek watershed is located in west central Illinois (Figure 1). The project area begins downstream of the Upper La Moine watershed at the confluence of the east fork and main stem of the La Moine River, approximately 15 miles south of the Mississippi River and Iowa/Illinois border. The project area continues through agricultural and forested land, ending downstream of Beardstown at the confluence with the Illinois River. The project area covers nearly 851 square miles, and includes land within Adams, Brown, Fulton, Hancock, McDonough and Schuyler Counties. Major tributaries along this stretch of the river include Bronson Creek, Troublesome Creek, Camp Creek, Flour Creek, Cedar Creek, Little Missouri and Missouri Creek, West Creek, the Town Branch of the La Moine River and Logan Creek.

2.1 Jurisdictions and Population

Counties with land in the watershed include Adams, Brown, Fulton, Hancock, McDonough and Schuyler. A portion of the city of Macomb is located in the headwaters of the watershed and the city itself accounts for approximately two-thirds of the population of McDonough County. The remaining developed areas are small towns (e.g., Camden and Ripley). County populations are area weighted (i.e., takes into account the proportional area) to the watershed in Table 2. To improve population estimates, the population of McDonough County was adjusted to include only the proportion of the city of Macomb within the watershed.

Table 2. Area weighted county populations within project area

County	2000	2010	Percent Change
Adams	4,404	4,328	-2%
Brown	2,878	2,873	0%
Fulton	41	40	-2%
Hancock	3,917	3,719	-5%
McDonough	9,142	8,815	-4%
Schuyler	3,990	4,187	5%
TOTAL	***24,372***	***23,962***	***-2%***

Source: U.S. Census Bureau

2.2 Climate

Climate data are available from the National Oceanic and Atmospheric Administration (NOAA) Global Historical Climatology Network Database (GHCND); Station USC00117551 is located in Rushville, IL in the southern portion of the La Moine/Missouri Creek watershed and was used for analysis. In general, the climate of the region is continental with hot, humid summers and cold winters. Table 3 contains historical temperature data collected at the Rushville climate station. From 1893 to 2014 the average high winter temperature in Rushville was 37.3 °F and the average high summer temperature was 85.4 °F.

From 1893 to 2014, the annual average precipitation in Rushville was approximately 36.4 inches, including approximately 19.5 inches of snowfall. In general, larger volumes of precipitation tend to occur between the months of April and September.

Table 3. Climate summary at Rushville (1893-2014)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average High ºF	34	39	51	64	74	83	88	86	79	67	52	39
Average Low ºF	17	21	31	42	52	61	65	63	55	44	32	22
Mean Temperature ºF	26	30	41	53	63	72	76	74	67	56	42	30
Average Precipitation (in)	1.8	1.5	2.8	3.8	4.3	4.1	3.6	3.5	3.8	2.8	2.4	2.0
Average snow fall (in)	5.3	4.6	3.3	0.7	0.0	0.0	0.0	0.0	0.0	0.1	1.1	4.4

Source: NOAA GHCND

2.3 Land Use and Land Cover

Land use in the watershed is heavily influenced by agriculture (Figure 2). There is a small amount of urban area surrounding the town of Rushville and other small towns in the watershed, but outside of agriculture the remainder of the watershed is mostly forested. Specific land use across the watershed includes agriculture – cultivated crops and pasture/hay (approximately 66 percent), forest (approximately 27 percent), and urban (approximately 5 percent). Corn and soybeans are the primary crops grown in the watershed and account for 26 and 21 percent of the total watershed area, respectively according to the 2013 USDA Cropland Data Layer. Forest is prevalent near streams where steep valley walls preclude row crop agricultural activities. Table 4 presents area and percent by land cover type. Table 5 summarizes land covers that are contributing to each of the impaired segments. Both tables were derived from the 2011 National Land Cover Database (MRLC 2015).

Table 4. Watershed land cover summary

Land Use / Land Cover Category	Acreage	Percentage
Cultivated Crops	282,540	52.0%
Deciduous Forest	148,059	27.2%
Hay/Pasture	73,812	13.6%
Developed, Low Intensity	15,620	2.9%
Developed, Open Space	10,493	1.9%
Woody Wetlands	6,660	1.2%
Developed, Medium Intensity	2,830	0.5%
Open Water	1,579	0.3%
Herbaceous	735	0.1%
Developed, High Intensity	527	0.1%
Barren Land	310	0.1%
Shrub/Scrub	272	0.1%
Emergent Herbaceous Wetlands	240	0.0%
Evergreen Forest	7	0.0%
Total	**543,684**	**100.0%**

Source: 2011 National Land Cover Database

Table 5. Land cover by impaired segment

Watershed	Segment ID	Watershed Area (square miles)	Cultivated Crops	Pasture /Hay	Developed	Forest	Grassland/ Herbaceous/ Shrub/Scrub	Barren Land	Wetlands and Water
			%						
La Moine River	IL_DG-01	851	51.9	13.6	5.4	27.2	0.2	0.1	1.6
La Moine River	IL_DG-04	396	60.1	12.9	5.7	19.8	0.2	0.1	1.2
Missouri Creek	IL_DGD-01	92	35.8	20.3	4.0	38.9	0.1	0	0.9
Little Missouri Creek	IL_DGDA-01	37	35.9	16.5	4.2	42.6	0.2	0	0.6

Source: 2011 National Land Cover Database

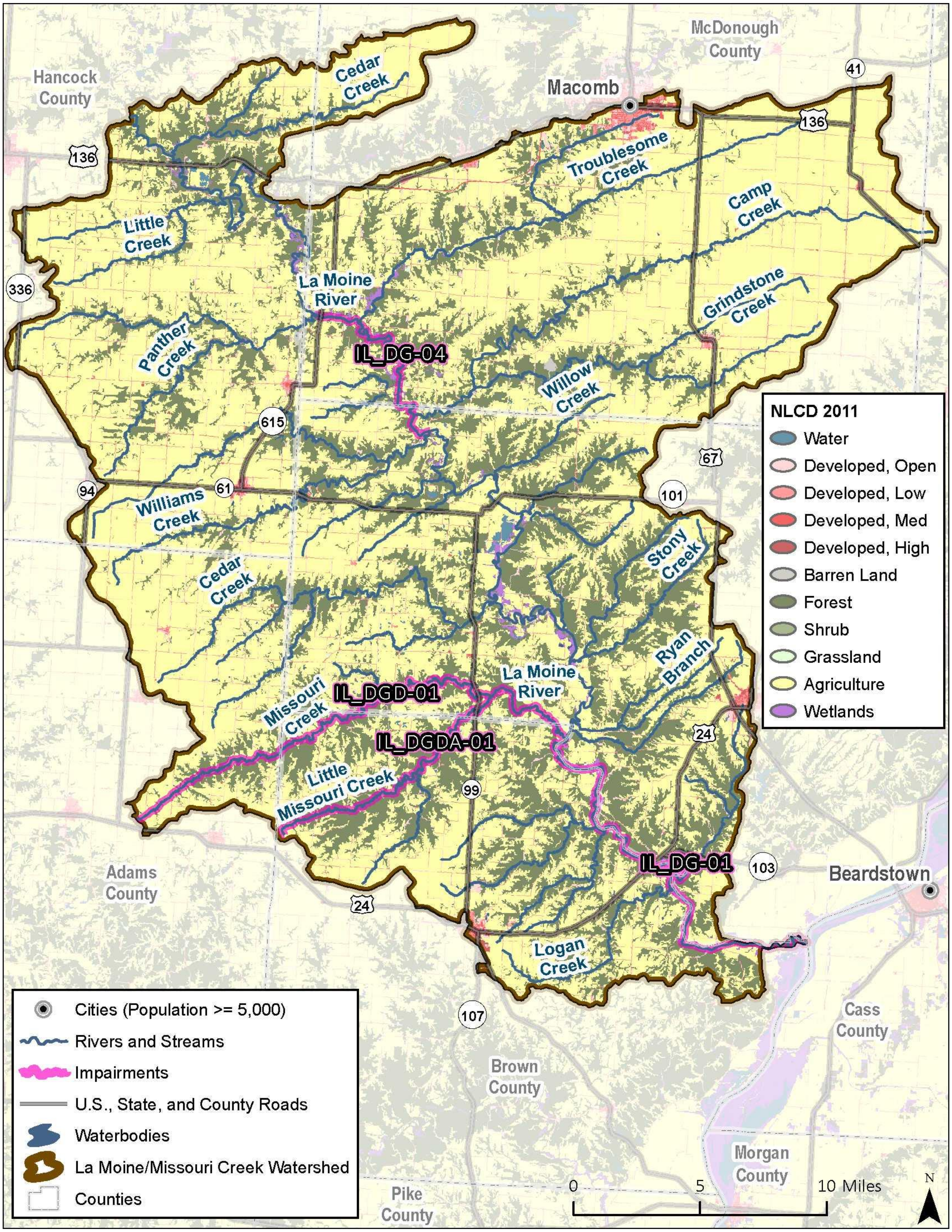

Figure 2. La Moine/Missouri Creek watershed land cover (2011 National Land Cover Database).

2.4 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by slope and elevation. The La Moine/Missouri Creek watershed varies in elevation from 425 to 810 feet (Figure 3). The La Moine River water elevation varies from 534 feet to 428 feet and is 86 miles long in the La Moine/Missouri Creek watershed, resulting in an average stream gradient of 1.2 feet per mile. The watershed consists of rolling hills with steep-walled wooded valleys (IDNR 2005).

2.5 Soils

The National Cooperative Soil Survey publishes soil surveys for each county within the U.S. These soil surveys contain predictions of soil behavior for selected land uses. The surveys also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the impact of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning, the identification of special practices needed to ensure proper performance, and mapping of hydrologic soil groups (HSGs) (NRCS 2007).

HSGs refer to the grouping of soils according to their runoff potential. Soil properties that influence the HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to slow permeable layer. There are four groups of HSGs: Group A, B, C, and Group D. Table 6 describes those HSGs found in the La Moine/Missouri Creek watershed area. Figure 4 and Table 7 summarizes the composition of HSGs per watershed.

Table 6. Hydrologic soil group descriptions (NRCS 2007)

HSG	Group Description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A-C/D	Dual Hydrologic Soil Groups. Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

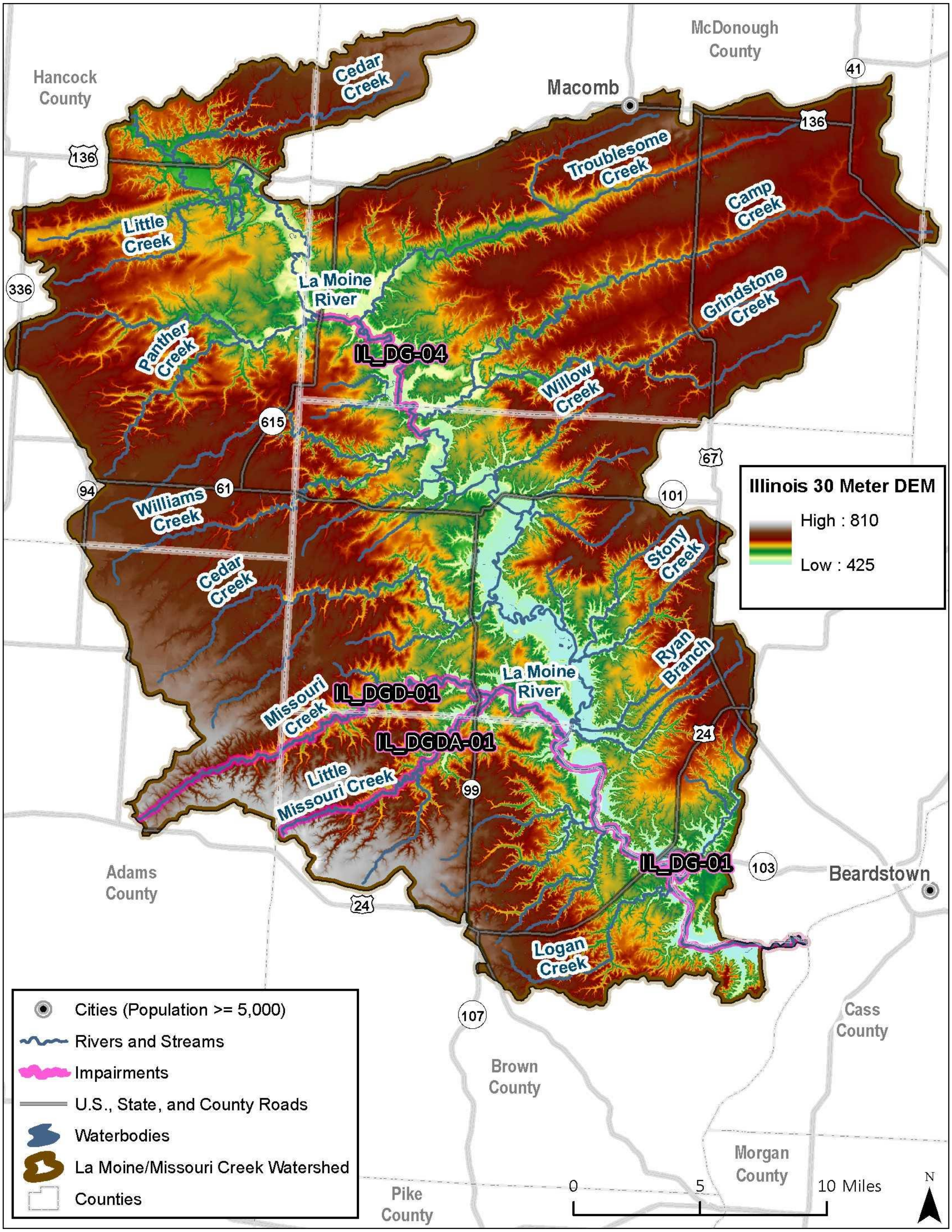

Figure 3. La Moine/Missouri Creek watershed land elevations (ISGS 2003).

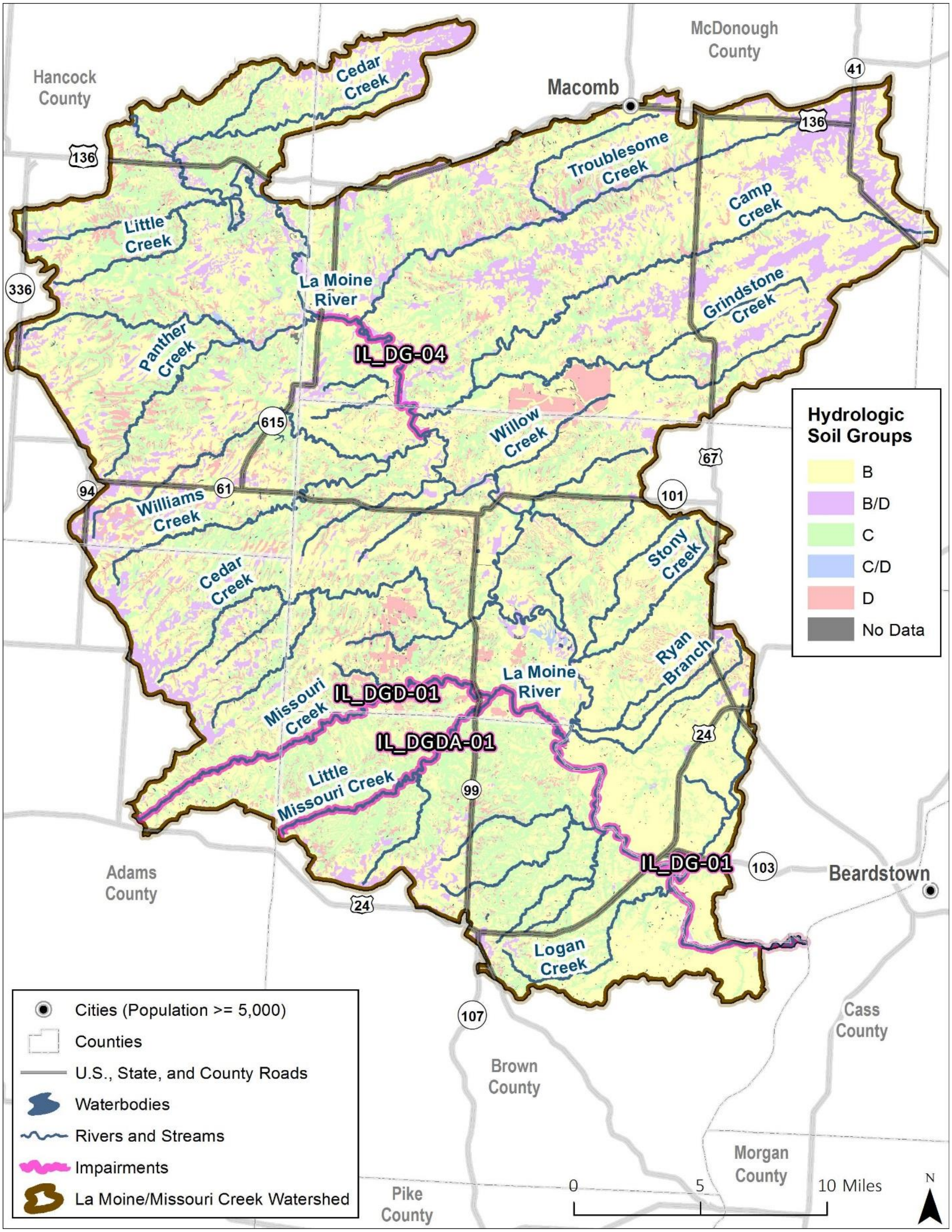

Figure 4. La Moine/Missouri Creek watershed hydrologic soil groups (Soil Surveys for Adams, Brown, Fulton, Hancock, McDonough and Schuyler Counties, Illinois; NRCS SSURGO Database 2011).

Table 7. Percent composition of hydrologic soil group per watershed

Watershed	Segment	A/D	B	B/D	C	C/D	D	No Data
		%						
La Moine River	IL_DG-01	0	54.5	9.9	27.6	0.2	7.4	0.4
La Moine River	IL_DG-04	0	53	15	25	0.2	6.5	0.3
Missouri Creek	IL_DGD-01	0	51	12.8	28.6	0.2	7.1	0.3
Little Missouri Creek	IL_DGDA-01	0	36	5.8	50.7	0	7.4	0.1

Source: NRCS SSURGO Database 2011

A commonly used soil attribute is the K-factor. The K-factor:

> *Indicates the susceptibility of a soil to sheet and rill erosion by water. (The K-factor) is one of six factors used in the Universal Soil Loss Equation to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS 2005).*

The distribution of K-factor values in the La Moine/Missouri Creek watershed range from 0.02 to 0.55, with an average value of 0.38 (Figure 5).

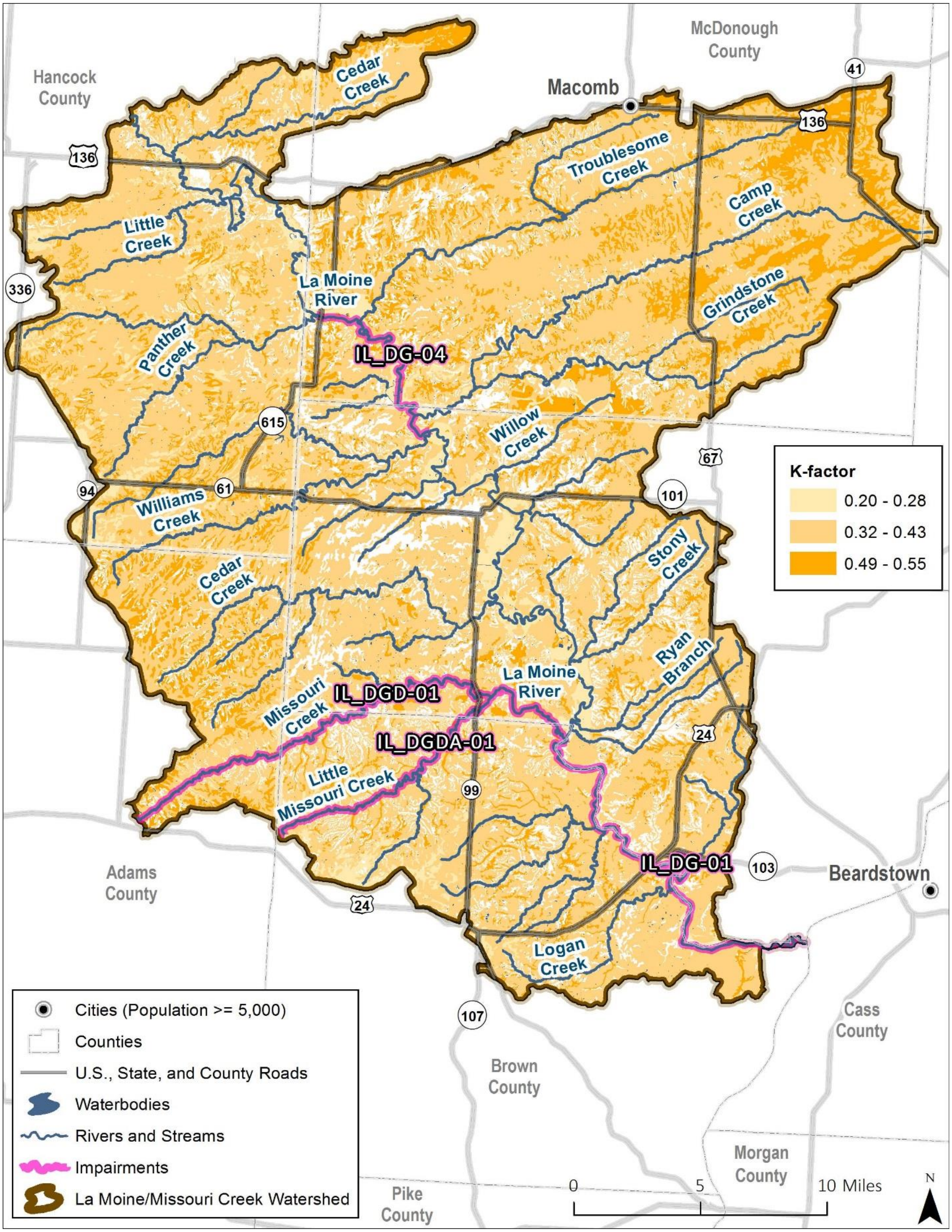

Figure 5. La Moine/Missouri Creek watershed soil K-factor values (Soil Surveys for Adams, Brown, Fulton, Hancock, McDonough and Schuyler Counties, Illinois; NRCS SSURGO Database 2011).

2.6 Hydrology and Water Quality

Hydrology plays an important role in evaluating water quality. The hydrology of the La Moine/Missouri Creek watershed is driven by local climate conditions and the landscape. The U.S. Geological Survey (USGS) has been collecting flow and water quality data in this watershed since the 1920s; Illinois EPA has been collecting water quality data since 1999.

2.6.1 USGS Flow Data

The USGS has monitored flow at several locations in the watershed (Table 8 and Figure 6). The daily average, peak history, and monthly flow data show the inherent variability associated with hydrology. Flow duration curves provide a way to address that variability and flow related water quality patterns. Duration curves describe the percentage of time during which specified flows are equaled or exceeded. Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period, based on measurements taken at uniform intervals (e.g., daily average or 15-minute instantaneous). Duration analysis results in a curve that relates flow values to the percent of time those values have been met or exceeded. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently. Flow duration curves for the active USGS gages are presented in Figure 7.

Table 8. USGS stream gages within project area

Gage ID	Watershed Area *(mi.^{2})*	Location	Period of Record	Impaired Segment
05584500	**655**	**La Moine River at Colmar, IL**	**1944-2015**	**IL_DG-04**
05584680	35.5	Grindstone Creek near Industry, IL	1979-1981	-
05584682	0.17	Grindstone Creek Trib No. 2 near Doddsville, IL	1981-1983	-
05584683	0.22	Grindstone Creek Tributary near Doddsville, IL	1980-1981	-
05584685	46.5	Grindstone Creek near Birmingham, IL	1979-1981	-
05584950	2.16	West Creek at Mount Sterling, IL	1961-1972	-
05585000	**1,293**	**La Moine River at Ripley, IL**	**1921-2015**	**IL_DG-01**

BOLD – indicates active USGS gage

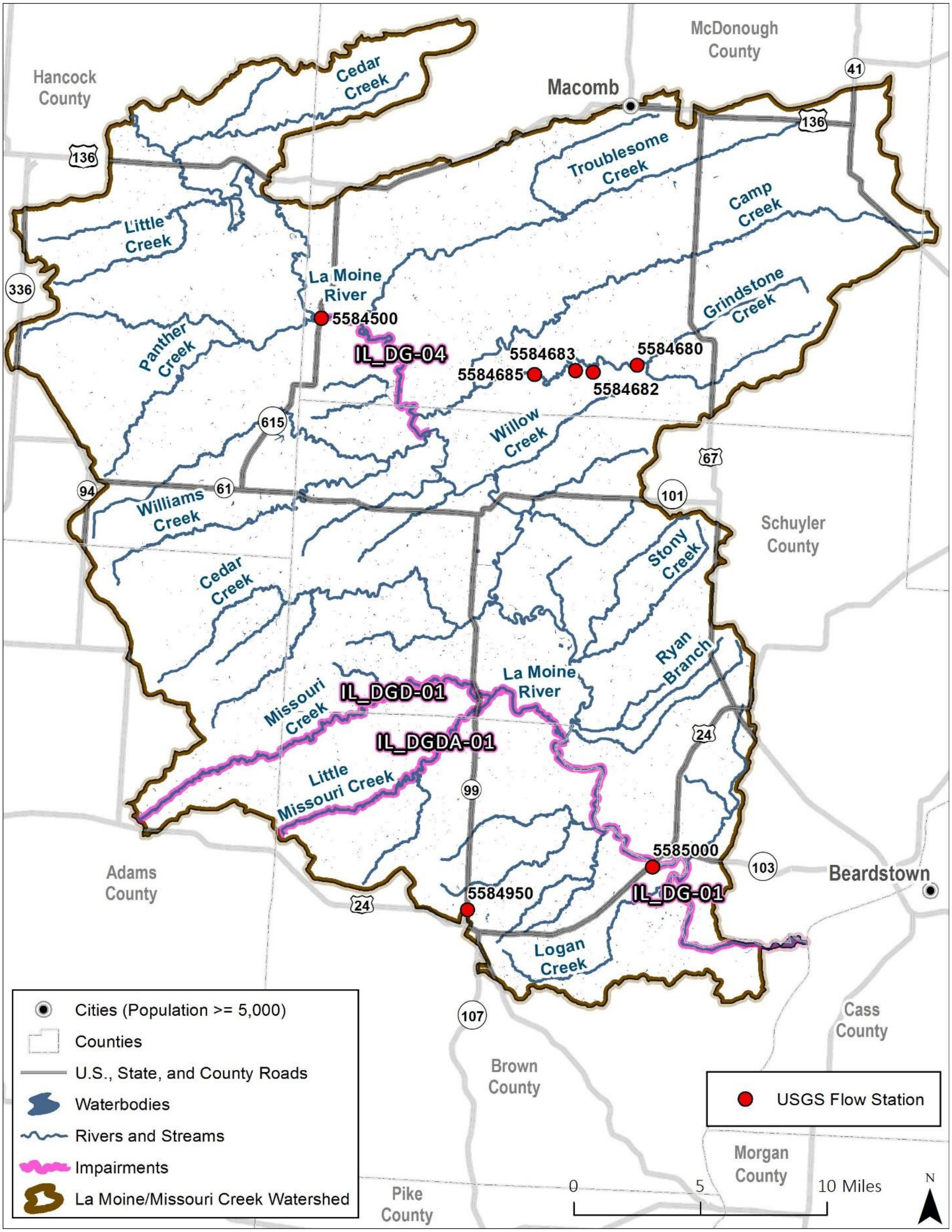

Figure 6. USGS stream gages within watershed.

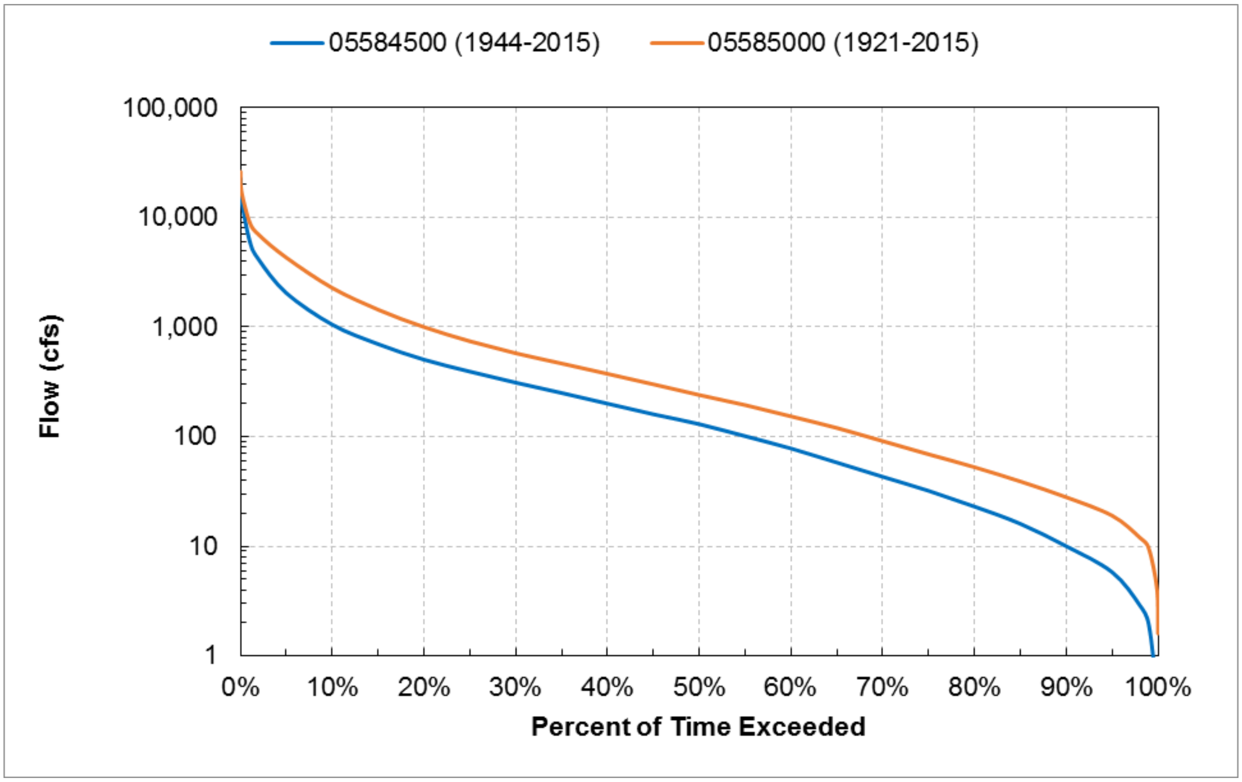

Figure 7. Flow duration curves for the active USGS gages in the La Moine/Missouri Creek watershed.

An evaluation of annual flow at USGS gages 05584500 and 05585000 on the La Moine River from 1944 to 2015, and 1921 to 2015, respectively, show that annual flow in 2014 was nearly at the median; thus, it is assumed that 2014 is a typical year. Flow at USGS gages 05584500 and 0558500 are plotted with precipitation from the National Oceanic and Atmospheric Administration (NOAA) Global Historical Climatology Network Database (GHCND) Station USC00117551 (Rushville) for 2014 in Figure 8.

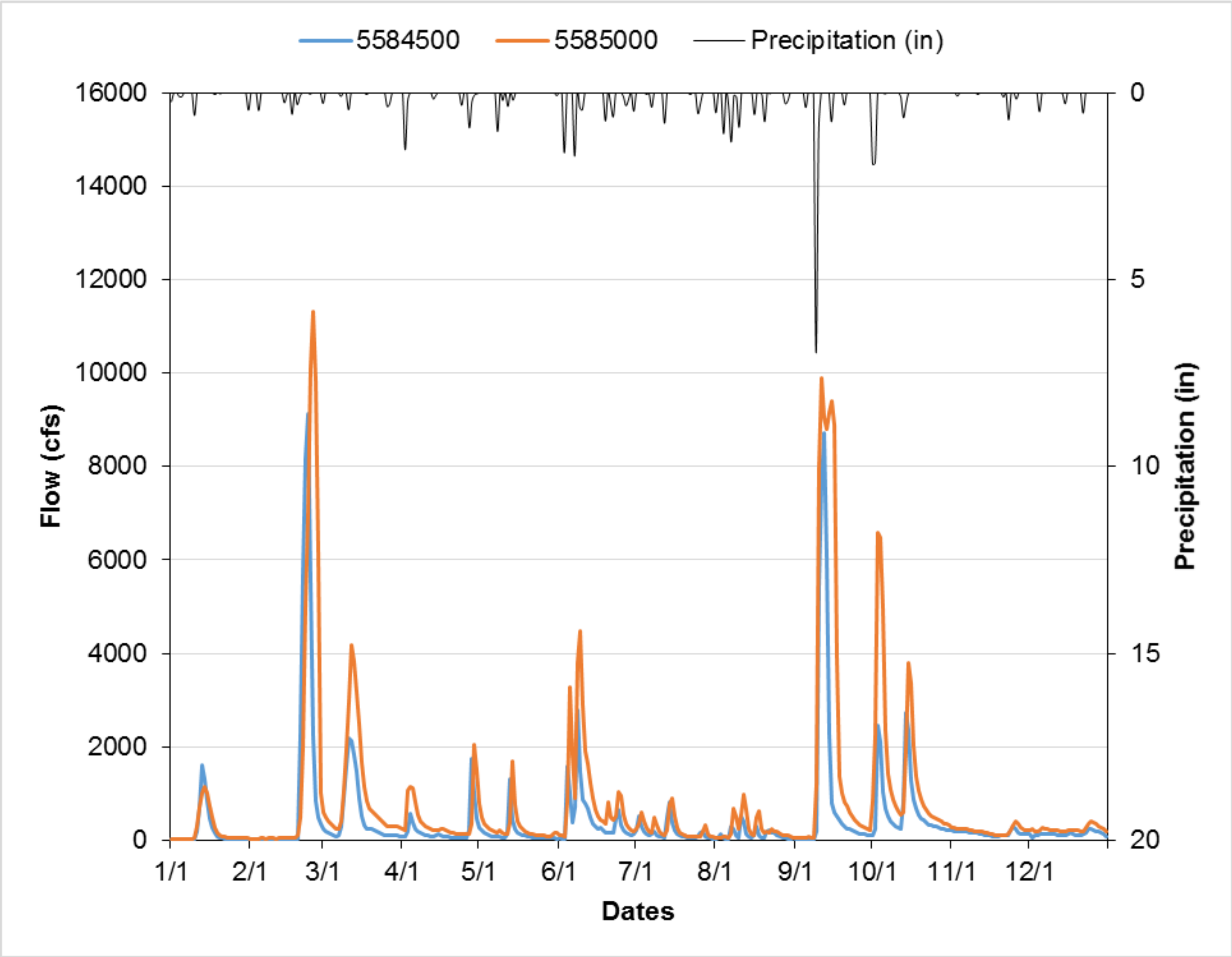

Figure 8. Daily flow in the La Moine River with daily precipitation at Rushville (USC00117551), 2014.

2.6.2 Illinois EPA Water Quality Monitoring

Routine water quality monitoring is a key part of the Illinois EPA assessment program. The goals of Illinois EPA surface water monitoring programs are to:

- Determine whether designated uses are supported
- Identify causes of pollution (toxics, nutrients, sedimentation) and sources (point or nonpoint) of surface water impairments
- Determine the overall effectiveness of pollution control programs
- Identify long term resource quality trends

Illinois EPA has operated a widespread, active long-term monitoring network in Illinois since 1977, known as the Ambient Water Quality Monitoring Network (AWQMN). The AWQMN is utilized by the Illinois EPA to:

- Provide baseline water quality information
- Characterize and define trends in the physical, chemical and biological conditions of the state's waters
- Identify new or existing water quality problems
- Act as a triggering mechanism for special studies or other appropriate actions

Additional uses of the data collected by the Illinois EPA through the AWQMN program include the review of existing water quality standards and establishment of water quality based effluent limits for NPDES permits. The AWQMN is integrated with other Illinois EPA chemical and biological stream monitoring programs including Intensive River Basin Surveys, Facility –Related Stream Surveys, Fish Contaminant Monitoring, Toxicity Testing Program and Pesticide Monitoring Subnetwork which are more regionally based (specific watersheds or point source receiving stream) and cover a shorter span of time (e.g. one year) to evaluate compliance with water quality standards and determine designated use support. Information from these programs is compiled by Illinois EPA into the Illinois Integrated Water Quality Report as required by the Federal Clean Water Act.

Within the La Moine/Missouri Creek watershed, data were found for numerous stations that are part of AWQMN (Figure 9 and Table 9). Parameters sampled on the streams include field measurements (water temperature) as well as those that require lab analyses (e.g., fecal coliform, nutrients, and total suspended solids). Many sites have historical data that are greater than 10 years old. Data were obtained directly from Illinois EPA.

Additional water quality data are also available at two USGS stations (Figure 6 and Table 9). Parameters sampled include suspended and dissolved solids, nutrients, dissolved oxygen, turbidity, fecal coliform, and metals.

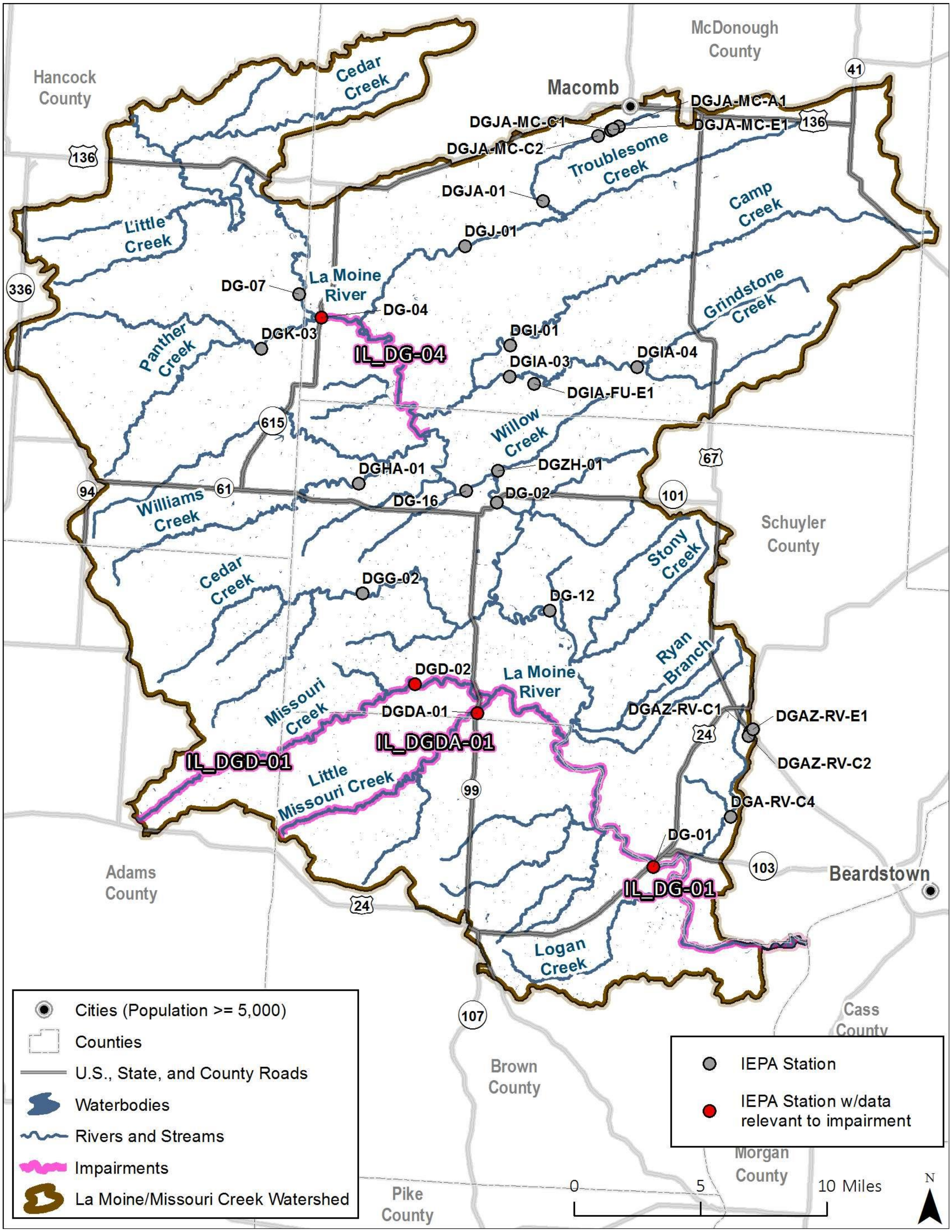

Figure 9. Illinois EPA water quality sampling sites within watershed.

Table 9. La Moine/Missouri Creek watershed water quality data

AWQMN Sites	USGS Gage	Water Body	Location	Period of Record
DG-01	05585000	La Moine River	Old US 24 (1500E) Br., 0.2 Mi. E of US 24 and 0.4 Mi. NE of Ripley	*1964-1997, 1999*-2013
DG-02	--		RT 101 Br. E Brooklyn	*2002*, 2012
DG-04	05584500		RT 61 Br., 0.9 Mi. S of St. Marys Rd. (1000N) and 1.2 Mi. SW of Colmar	*1957*-2013
DG-07	--		CO Rd. 6 Br. 1.25 Mi. W Colmar	2007, 2011-2012
DG-12	--		Greenwell Rd. Br. 3 Mi. NE Camden	*2002*
DG-16	--		CO Rd. 660E Br. 1 Mi. N and 0.6 Mi. W of Brooklyn	2007, 2012
DGA-RV-C4	--	Town Branch	West Branch Rd. Br. 4 Mi. S of Rushville and 4 Mi. downstream Rushville STP	2007
DGAZ-RV-C1	--	Rushville STP Trib	US 67 Br. 300 yds. downstream Rushville STP	2007
DGAZ-RV-C2	--		Parkview Rd., 0.75 Mi. S of Rushville and 0.4 Mi downstream Rushville STP	2007
DGAZ-RV-E1	--		Rushville STP, S Liberty St. (CR 1), 0.5 Mi. S of Rushville	2007
DGD-02	--	Missouri Creek	3 Mi. SW Camden dirt road	*2002*, 2007, 2012
DGDA-01	--	Little Missouri Creek	IL RT 99 Br. 3 Mi. S Camden	*2002*, 2012
DGG-02	--	Cedar Creek - South	1.25 Mi. S Huntsville TWP Rd. Br.	*2002*, 2007, 2012
DGHA-01	--	Williams Creek	5.5 Mi. E Augusta at dirt rd. ford	*2002*, 2007, 2012
DGI-01	--	Camp Creek	3.5 Mi S Fandon TWP Rd. Br.	*2002-2003*, 2007, 2012
DGIA-03	--	Grindstone Creek	4.5 Mi S Fandon CO Rd. #8	*2002-2003*, 2007, 2012
DGIA-04	05584680		3 Mi. SW Industry TWP Rd.	*1979-1981*, *2003*
--	05584682		Grindstone Creek Trib No. 2 near Doddsville, IL	*1982-1983*
--	05584683		Grindstone Creek Tributary near Doddsville, IL	*1981*
--	05584685		Grindstone Creek near Birmingham, IL	*1979-1981*
DGIA-FU-E1	--		Outfall #19 at mine near Industry	*2003*
DGJ-01	--	Troublesome Creek	3 Mi. S Colchester	*2002*, 2007, 2012
DGJA-01	--	Killjordan Creek	4 Mi. SW Macomb CO Rd. #18	2012
DGJA-MC-A1	--		Near corner W Grant St. and S Garfield St., 0.4 Mi. upstream of Macomb STP	2007
DGJA-MC-C1	--		Cherokee Rd. Br. 100 yds. downstream of Macomb STP	2007
DGJA-MC-C2	--		SW of Macomb and 0.5 Mi. downstream of Macomb STP	2007

AWQMN Sites	USGS Gage	Water Body	Location	Period of Record
DGJA-MC-E1	--		Macomb STP, 901 W Grant St. SW edge of Macomb	2007
DGK-03	--	Bronson Creek	CO Rd. 2900E 1.5 Mi. NW of Plymouth	*2002*
DGZH-01	--	Willow Creek	2 Mi. N Brooklyn	*2003*

Italics – Data are greater than 10 years old
STP – Sewage treatment plant

3. Watershed Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. This section provides a summary of potential watershed-wide sources that contribute listed pollutants to the La Moine/Missouri Creek watershed.

3.1 Pollutants of Concern

Pollutants of concern evaluated within this source assessment include fecal coliform, manganese, and oxygen demanding substances. These pollutants can originate from an array of sources including point and nonpoint sources. Point sources typically discharge at a specific location from pipes, outfalls, and conveyance channels. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters, particularly overland runoff. This section provides a summary of potential point and nonpoint sources that contribute pollutants to the impaired waterbodies.

3.2 Point Sources

Point source pollution is defined by the Federal Clean Water Act (CWA) §502(14) as:

> *"any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture storm water discharges and return flow from irrigated agriculture."*

Point sources in the watershed include facilities such as municipal wastewater treatment plants (WWTPs), industrial facilities, and concentrated animal feeding operations (CAFO). Stormwater can also be regulated including municipal separate storm sewer systems, however there are no regulated municipal separate storm sewer systems in the watershed. Under the CWA, all point sources are regulated under the NPDES program. NPDES permit holders in the watershed are discussed below.

3.2.1 NPDES Facilities (Non-CAFO)

A municipality, industry, or operation must apply for an NPDES permit if an activity at that facility discharges wastewater to surface water. Examples of NPDES facilities within the study area include municipal and industrial wastewater treatment plants. Bacteria and oxygen demanding substances (e.g., nutrients, biochemical oxygen demand) can be found in these discharges.

There are 11 individual NPDES permitted facilities within the watershed. Table 10 and Figure 10 include each NPDES permitted facility within the watershed. Average and maximum design flows and downstream impairments are included in the facility summaries. Four WWTPs have disinfection exemptions in the watershed which allow a facility to discharge wastewater without disinfection. Facilities with disinfection exemptions may be required to provide Illinois EPA with updated information to demonstrate compliance with these requirements and facilities directly discharging into a fecal-impaired segment may have their disinfection exemption revoked through future NPDES permitting actions.

Table 10. Individual NPDES permitted facilities

IL Permit ID	Facility Name	Facility Type	Receiving Water	Downstream Impairment	Average Design Flow (MGD)	Maximum Design Flow (MGD)	Disinfection Exemption
IL0022411	MT STERLING, CITY OF	STP	UNNAMED TRIB TO WEST CREEK	DG-01	0.366	0.54	Yes
IL0027570	AUGUSTA STP	STP	UNNAMED TRIB OF WILLIAMS CREEK	DG-04, DG-01	0.093	0.2325	Yes
IL0028177	COLCHESTER, CITY OF	STP	UNNAMED TRIB OF EAST FORK OF LAMOINE RIVER	DG-04, DG-01	0.17	0.47	Yes
IL0029688	MACOMB, CITY OF	STP	KILJORDAN CREEK	DG-04, DG-01	3.0	7.5	Yes
IL0042153	PLYMOUTH, VILLAGE OF	STP	UNNAMED TRIB TO BRONSON CREEK	DG-04, DG-01	0.06	0.3	--[a]
IL0054267	COUNTRY AIRE ESTATES MHP	STP	UNNAMED TRIB TO KILLJORDAN CREEK	DG-04, DG-01	0.0126	0.0315	Yes
ILG580048	INDUSTRY, VILLAGE OF	STP	GRINDSTONE CREEK	DG-04, DG-01	0.075	0.1875	Yes
ILG640235	CLAYTON CAMP POINT WATER COMMISSION	Public water supply	BRANCH OF LOGAN CREEK	DG-01	*NA*	*NA*	--[a]
ILG840080	CENTRAL STONE CO	Non-coal mining	LAMOINE RIVER	DG-04, DG-01	*NA*	*NA*	--[a]
ILG840189	CENTRAL STONE COMPANY	Non-coal mining	WATERS OF THE STATE	DG-04, DG-01	*NA*	*NA*	--[a]
ILG840208	R L O'NEAL AND SONS INC	Non-coal mining	UNNAMED TRIB TO BRONSON CREEK	DG-04, DG-01	*NA*	*NA*	--[a]

MGD – Million gallons per day
STP – Sewage treatment plant
a. No fecal coliform limit in current permit

3.2.2 CAFOs

The area that produces manure, litter, or processed wastewater as the result of CAFOs is considered a point source that is regulated through the NPDES Program. In Illinois, the CAFO program is administered by the Illinois EPA through general permit number ILA01 (refer to the following Web site for more details: http://www.epa.state.il.us/water/cafo/). The federal regulations for all CAFOs can be found in 40 CFR Parts 9, 122, and 412.U.S. EPA requires that CAFOs receive a WLA as part of the TMDL development process. The WLA is typically set at zero for all pollutants. There are two CAFOs in the La Moine/Missouri Creek watershed: North Fork Pork – Carthage (ILA010085) and Pinnacle Genetics (ILA010002). Both facilities are located within the Troublesome Creek watershed. Troublesome Creek drains to impaired segment DG-04 of the La Moine River.

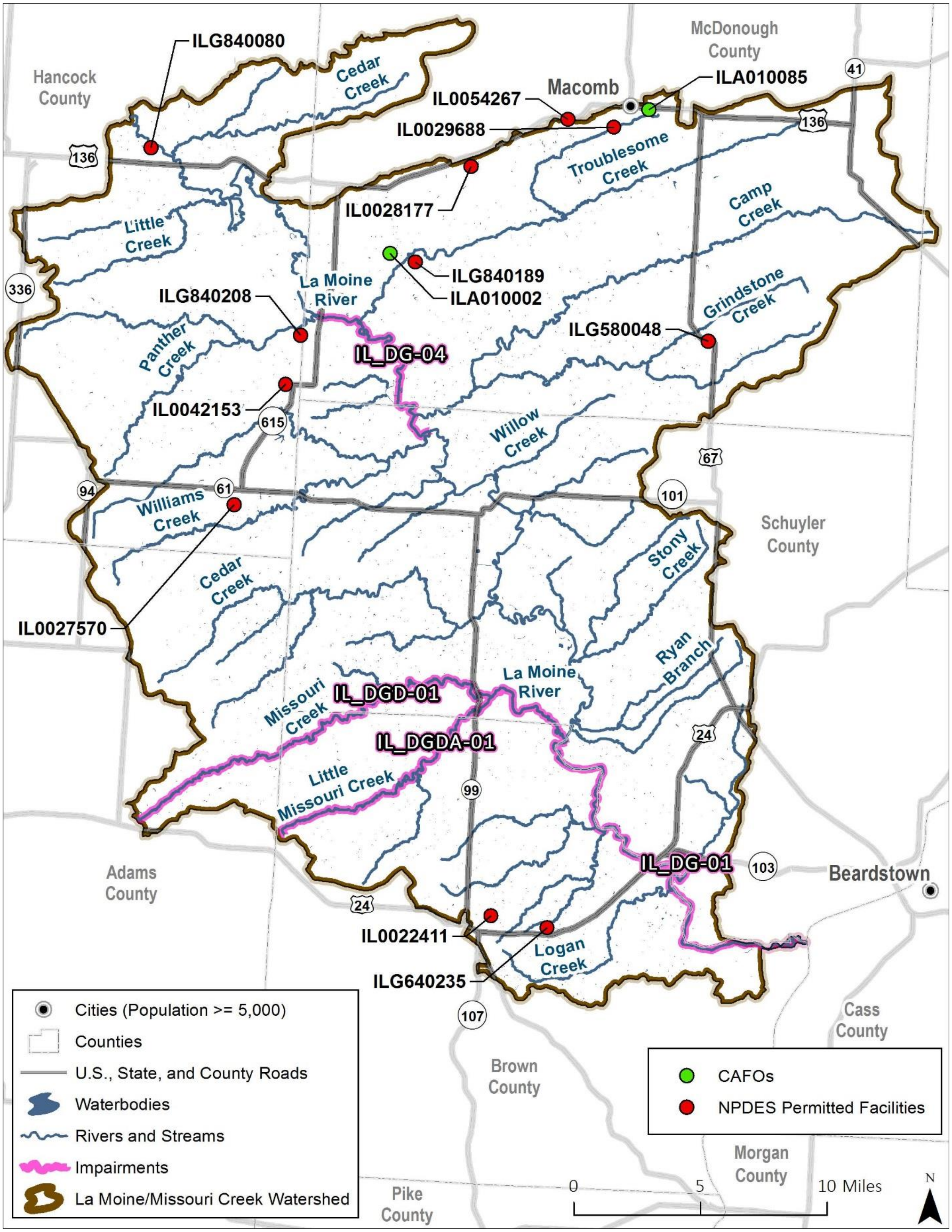

Figure 10. Point sources within watershed.

3.3 Nonpoint Sources

The term nonpoint source pollution is defined as any source of pollution that does not meet the legal definition of point sources. Nonpoint source pollution typically results from overland stormwater runoff that is diffuse in origin, as well as background conditions. With agricultural practices such as crop cultivation (52 percent) and pasture/hay (14 percent) covering an estimated 66 percent of the project area, nonpoint source pollution may contribute a significant amount of the total pollutant load. In addition to runoff and erosion, significant nonpoint sources also include septic systems, animal agriculture, and agricultural tile drainage. There is a history of coal mining in the watershed, primarily in McDonough, Schuyler, and Brown counties. Historical strip mining and underground mining activities in the watershed have resulted in erosion and acid runoff. To limit ongoing historic mine activity impacts, several Illinois agencies have cleaned up abandoned mine sites, where feasible, by converting the land to public recreation and wildlife habitat. Most notably, Argyle Lake State Park, located north of Colchester in the central portion of the watershed, consists of 1,500 acres of mine land reclaimed in 1949 (IDNR 2005). Illinois EPA has identified several nonpoint sources as contributing to the La Moine/Missouri Creek watershed impairments such as crop production, impacts from abandoned mine lands and surface mining (Table 11).

Table 11. Potential sources in project area based on 2014 305(b) list

Watershed	Segment	Causes	Sources
La Moine River	IL_DG-01	Fecal Coliform	Source Unknown
La Moine River	IL_DG-04	Fecal Coliform	Source Unknown
Missouri Creek	IL_DGD-01	Manganese	Source Unknown
Little Missouri Creek	IL_DGDA-01	Manganese and Dissolved Oxygen	Impacts from Abandoned Mine Lands (Inactive), Surface Mining and Crop Production (Crop Land or Dry Land)

3.3.1 Stormwater Runoff

During wet-weather events (snowmelt and rainfall), pollutants are incorporated into runoff and can be delivered to downstream waterbodies. The resultant pollutant loads are linked to the land uses and practices in the watershed. Agricultural and developed areas can have significant effects on water quality if proper best management practices are not in place. The main pollutants of concern associated with agricultural runoff are sediment, nutrients, pesticides, and bacteria. Storm water from developed areas can be contaminated with oil, grease, chlorides, pesticides, herbicides, nutrients, viruses, bacteria, metals, and sediment.

In addition to pollutants, alterations to a watershed's hydrology as a result of land use changes can detrimentally affect habitat and biological health. Imperviousness associated with developed land uses and agricultural field tiling can result in increased peak flows and runoff volumes and decreased base flow as a result of reduced ground water discharge. The increased peak flows and runoff volumes tend to increase streambank erosion. These more powerful flows have greater ability to move larger sediment particles farther, which may result in downstream sedimentation when the in-stream flow decreases and slows down. Drain tiles also transport agricultural runoff directly to ditches and streams, whereas runoff flowing over the land surface may infiltrate to the subsurface and may flow through vegetated riparian areas.

3.3.2 Erosion

Erosion of sediments can be a source of high manganese in the watershed. Manganese is naturally occurring within the glaciated soils in the watershed. Various forms of erosion are a common source of sediment. Typically, erosion will increase as stream velocity and peak flow increases. Runoff over impervious surfaces and through agricultural drain tiles will have higher velocities and peak flows, and thus, increase erosion.

Sheet erosion is the detachment of soil particles by raindrop impact, and their removal by water flowing overland as a sheet instead of in channels or rills. Rill erosion refers to the development of small, ephemeral concentrated flow paths, which function as both sediment source and sediment delivery systems for erosion on hillsides. Sheet and rill erosion occur more frequently in areas that lack or have sparse vegetation. Bank and channel erosion refers to the wearing away of the banks and channel of a stream or river. High rates of bank and channel erosion can often be associated with water flow and sediment dynamics being out of balance that can result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. Hydrology is a major driver for both sheet/rill and stream channel erosion.

Figure 11. Examples of erosion: Top picture is bank/channel erosion; Bottom picture is sheet and rill erosion.

3.3.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include: seasonal high water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restrict water flow and root penetration). When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsely and Witten 1996). Septic systems contain wastewater from homes and businesses and can be significant sources of pathogens and nutrients. Watershed specific data are not available for septic systems. However, county wide data available from the National Environmental Service Center for 1992 and 1998 are available and area weighted to estimate the number of septic systems in each watershed (Table 12).

Table 12. Estimated (area weighted) septic systems

Watershed	Number of septic systems	Septic systems per square mile
La Moine River (IL_DG-01)	8,073	9
La Moine River (IL_DG-04)	3,666	9
Missouri Creek (IL_DGD-01)	851	9
Little Missouri Creek (IL_DGDA-01)	316	9

Source: NESC 1992 and 1998 (data obtained from EPA Region 5 STEPL Model database)

3.3.4 Animal Feeding Operations (AFOs)

Animal feeding operations that are not classified as CAFOs are known as animal feeding operations (AFOs) in Illinois. Non-CAFO AFOs are considered nonpoint sources by U.S. EPA. AFOs in Illinois do not have state permits. However, they are subject to state livestock waste regulations and may be inspected by the Illinois EPA, either in response to complaints or as part of the Agency's field inspection responsibilities to determine compliance by facilities subject to water pollution and livestock waste regulations.

The animals raised in AFOs produce manure that is stored in pits, lagoons, tanks and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. AFOs, however, can pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure over application can adversely impact soil productivity.

Livestock are potential sources of bacteria, nutrients, and other oxygen demanding substances to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county wide data available from the 2012 Census of Agriculture were downloaded and area weighted to estimate animal populations in the watershed (Table 13). An estimated 119,749 animals are in the watershed.

Table 13. Estimated (area weighted) livestock animals

Watershed	Cattle	Poultry	Sheep	Hogs	Horses
La Moine River (IL_DG-01)	18,579	697	826	99,098	549
La Moine River (IL_DG-04)	9,560	378	526	48,843	307
Missouri Creek (IL_DGD-01)	1,823	70	82	7,343	59
Little Missouri Creek (IL_DGDA-01)	602	16	35	2,323	25

Source: 2012 Census of Agriculture (Illinois)

4. TMDL Endpoints

This section presents information on the water quality impairments within the La Moine/Missouri Creek watershed and the associated water quality standards (WQS) and targets.

4.1 Applicable Standards

WQS are designed to protect beneficial uses. The authority to designate beneficial uses and adopt WQS is granted through Title 35 of the Illinois Administrative Code. Designated uses to be protected in surface waters of the state are defined under Section 303, and WQS are designated under Section 302 (Water Quality Standards). Designated uses and water quality criteria are discussed below.

4.1.1 Designated Uses

Illinois EPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB) to assess the designated use support for Illinois waterbodies. The following are the use support designations provided by the IPCB that apply to water bodies in the La Moine/Missouri Creek watershed:

General Use Standards – These standards protect for aquatic life, wildlife, agricultural uses, primary contact (where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing), secondary contact (any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity), and most industrial uses. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

4.1.2 Illinois Water Quality Standards

Environmental regulations for the State of Illinois are contained within the Illinois Administrative Code, Title 35. Specifically, Title 35, Part 302 contains water quality standards promulgated by the Illinois Pollution Control Board. This section presents the standards applicable to impairments within the study area. Water quality standards and TMDL endpoints to be used for TMDL development in the La Moine/Missouri Creek watershed are provided in Table 14. There are no proposed LRSs in this watershed.

Table 14. Summary of water quality standards and TMDL endpoints for the La Moine/Missouri Creek watershed

Parameter	Units	General Use Water Quality Standard
Fecal Coliform [a]	#/100 ml	400 in <10% of samples [b]
		Geometric mean < 200 [c]
Manganese (dissolved)	µg/L	Acute standard: $e^{A+Bln(H)} \times 0.9812$, where A=4.9187 and B=0.7467; H=hardness Chronic standard: $e^{A+Bln(H)} \times 0.9812$, where A=4.0635 and B=0.7467; H=hardness
Dissolved Oxygen	mg/L	*Instantaneous minimum:* 5.0 *(March – July)* 3.5 *(August – February)*
		Daily minimum averaged over 7 days: 4.0 *(August – February)*
		Daily mean averaged over 7 days: 6.0 *(March - July)* 5.5 *(August – February)*

a. Fecal coliform standards are applicable for the recreation season only (May through October).
b. Standard shall not be exceeded by more than 10% of the samples collected during a 30 day period.
c. Geometric mean based on minimum of 5 samples taken over not more than a 30 day period.

According to Illinois water quality standards, primary contact means ...*any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing* (35 Ill. Adm. Code 301.355). The assessment of primary *contact* use is based on fecal coliform bacteria data. The General Use Water Quality Standard for fecal coliform bacteria specifies that during the months of May through October, based on a minimum of five samples taken over not more than a 30-

day period, fecal coliform bacteria counts shall not exceed a geometric mean of 200/100 ml, nor shall more than 10 percent of the samples during any 30-day period exceed 400/100 ml (35 Ill. Adm. Code 302.209). This standard protects primary contact use of Illinois waters by humans.

Due to limited state resources, fecal coliform bacteria is not normally sampled at a frequency necessary to apply the General Use standard, i.e., at least five times per month during May through October, and very little data available from others are collected at the required frequency. Therefore, assessment guidelines are based on application of the standard when sufficient data is available to determine standard exceedances; but, in most cases, attainment of primary contact use is based on a broader methodology intended to assess the likelihood that the General Use standard is being attained.

To assess primary contact use, Illinois EPA uses all fecal coliform bacteria from water samples collected in May through October, over the most recent five-year period (i.e., 2011 through 2015 for this report). Based on these water samples, geometric means and individual measurements of fecal coliform bacteria are compared to the concentration thresholds in Table 15 and Table 16. To apply the guidelines, the geometric mean of fecal coliform bacteria concentration is calculated from the entire set of May through October water samples, across the five years. No more than 10 percent of all the samples may exceed 400/100 ml for a water body to be considered Fully Supporting.

Table 15. Guidelines for Assessing Primary Contact Use in Illinois Streams and Inland Lakes

Degree of Use Support	Guidelines
Fully Supporting (Good)	No exceedances of the fecal coliform bacteria standard in the last five years <u>and</u> the geometric mean of all fecal coliform bacteria observations ≤200/100 ml, <u>and</u> ≤10% of all observations exceed 400/100 ml.
Not Supporting (Fair)	One exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard) <u>or</u> The geometric mean of all fecal coliform bacteria observations in the last five years ≤200/100 ml, <u>and</u> >10% of all observations in the last five years exceed 400/100 ml <u>or</u> The geometric mean of all fecal coliform bacteria observations in the last five years >200/100 ml, <u>and</u> ≤25% of all observations in the last five years exceed 400/100 ml.
Not Supporting (Poor)	More than one exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard) <u>or</u> The geometric mean of all fecal coliform bacteria observations in the last five years >200/100 ml, <u>and</u> >25% of all observations in the last five years exceed 400/100 ml

Table 16. Guidelines for Identifying Potential Causes of Impairment of Primary Contact Use in Illinois Streams and Freshwater Lakes

Potential Cause	Basis for Identifying Cause - Numeric Standard[1]
Fecal Coliform	Geometric mean of at least five fecal coliform bacteria observations collected over not more than 30 days during May through October >200/100 ml or > 10% of all such fecal coliform bacteria observations exceed 400/100 ml or Geometric mean of all fecal coliform bacteria observations (minimum of five samples) collected during May through October >200/100 ml or > 10% of all fecal coliform bacteria observation exceed 400/100 ml.

1. The applicable fecal coliform standard (35 Ill. Adm. Code, 302, Subpart B, Section 302.209) requires a minimum of five samples in not more than a 30-day period. However, because this number of samples is seldom available in this time frame, the criteria are also based on a minimum of five samples over the most recent five-year period.

Aquatic life use assessments in streams are typically based on the interpretation of biological information, physicochemical water data and physical-habitat information from the Intensive Basin Survey, Ambient Water Quality Monitoring Network or Facility-Related Stream Survey programs. The primary biological measures used are the fish Index of Biotic Integrity (fIBI; Karr et al. 1986; Smogor 2000, 2005), the macroinvertebrate Index of Biotic Integrity (mIBI; Tetra Tech 2004) and the Macroinvertebrate Biotic Index (MBI; Illinois EPA 1994). Physical habitat information used in assessments includes quantitative or qualitative measures of stream bottom composition and qualitative descriptors of channel and riparian conditions. Physicochemical water data used include measures of ―conventional parameters (e.g., dissolved oxygen, pH and temperature), priority pollutants, non-priority pollutants, and other pollutants (USEPA 2002 and www.epa.gov/waterscience/criteria/wqcriteria.html). In a minority of streams for which biological information is unavailable, aquatic life use assessments are based primarily on physicochemical water data.

When a stream segment is determined to be Not Supporting aquatic life use, generally, one exceedance of an applicable Illinois water quality standard (related to the protection of aquatic life) results in identifying the parameter as a potential cause of impairment. Additional guidelines used to determine potential causes of impairment include site-specific standards (35 Ill. Adm. Code 303, Subpart C), or adjusted standards (published in the Illinois Pollution Control Board's Environmental Register at http://www.ipcb.state.il.us/ecll/environmentalregister.asp).

5. Data Analysis

An important step in the TMDL development process is the review of water quality conditions, particularly data and information used to list segments. This section provides a review of available water quality information provided by Illinois EPA and USGS. All relevant data are presented below; however data that are greater than 10 years old are not used when evaluating impairment status. Each data point was reviewed to ensure the use of quality data in the analysis below.

For each impaired segment, the available data are summarizes and presented with the minimum, maximum, and average concentrations. The coefficient of variation (CV) is also included to provide a measure of the extent of variability as relates to the mean. The number of exceedances of the standard are also provided.

5.1 La Moine River

The La Moine River is listed as impaired along two segments: DG-01 and DG-04. DG-04 is listed as impaired due to fecal coliform. DG-01 is downstream of DG-04 and is also impaired for primary contact recreation due to fecal coliform. There is one Illinois EPA sampling site on each of the impaired reaches.

5.1.1 DG-04

Illinois EPA collected a total of 9 fecal coliform samples at DG-04 from 2011-2013 (Table 17 and Figure 12). There are 2 reported exceedances of the 400 cfu/100 mL single sample maximum standard, with an average reported value above the standard at 1,089 cfu/100 mL. Historical data at the site from 1990-2006 and 2009-2010 have a similar trend with 37 reported exceedances and an average well above the standard.

Table 17. Data summary, La Moine River DG-04

Sample Site	No. of samples	Minimum (cfu/100 mL)	Average (cfu/100 mL)	Maximum (cfu/100 mL)	CV (standard deviation/ average)	Number of exceedances of the single sample maximum standard (400 cfu/100 mL)
Fecal Coliform						
DG-04 (USGS 05584500)	9	24	1,089	7,900	2.23	2
DG-04 (USGS 05584500)[a]	114	5	2,379	52,000	3.09	37

a. Data from 1990-2006 and 2009-2010; greater than 5 years old.

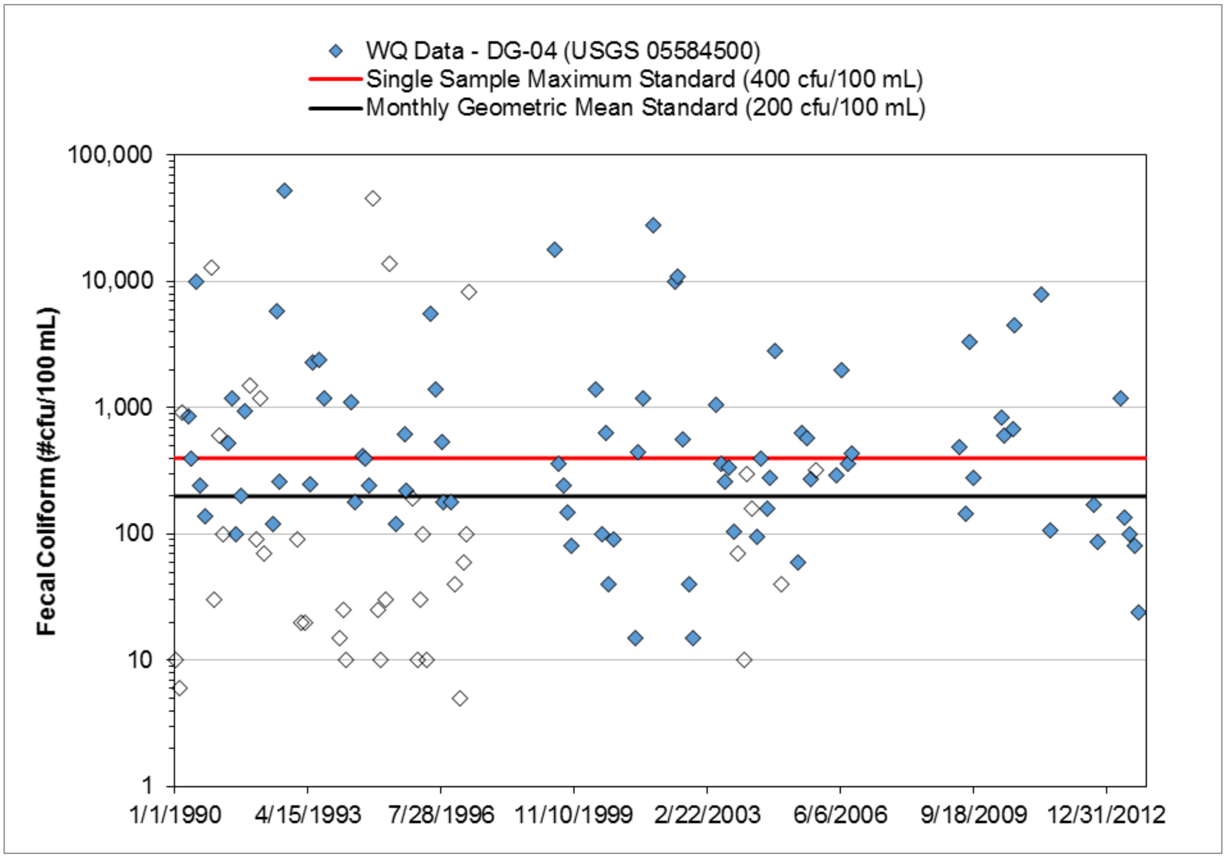

Figure 12. Fecal coliform water quality time series, La Moine River DG-04. Unfilled points indicate samples outside the standard window.

Possible causes for high bacteria concentrations include NPDES-permitted facilities, livestock, and onsite wastewater treatment systems. A total of nine NPDES-permitted facilities discharge to the impaired segment or within the watershed. In addition, livestock (including two CAFOs) and onsite wastewater treatment systems in the watershed amount to approximately 150 animal units per square mile and nine systems per square mile, respectively. Wildlife can also be a source of fecal coliform with almost 20 percent of the watershed in forest, providing habitat for deer and other wildlife.

5.1.2 DG-01

DG-01 is located at the mouth of the watershed, and therefore sources of pollutants present within the entire La Moine/Missouri Creek watershed potentially affect this impaired stream segment. Illinois EPA collected 14 fecal coliform samples at DG-01 from 2011-2013 (Table 18 and Figure 13). There are 2 reported exceedances of the 400 cfu/100 mL single sample maximum standard, with an average reported value above the standard at 922 cfu/100 mL. Illinois EPA historic data at the site prior to 2011 have a similar trend with 35 reported exceedances and an average well above the single sample maximum standard.

Table 18. Data summary, La Moine River DG-01

Sample Site	No. of samples	Minimum (cfu/100 mL)	Average (cfu/100 mL)	Maximum (cfu/100 mL)	CV (standard deviation/ average)	Number of exceedances of the single sample maximum standard (400 cfu/100 mL)
Fecal Coliform						
DG-01 (USGS 05585000)	14	41	922	9,500	2.63	2
DG-01 (USGS 05585000)[a]	113	5	2,005	40,000	2.91	35

a. Data from 1990-2010; greater than 5 years old.

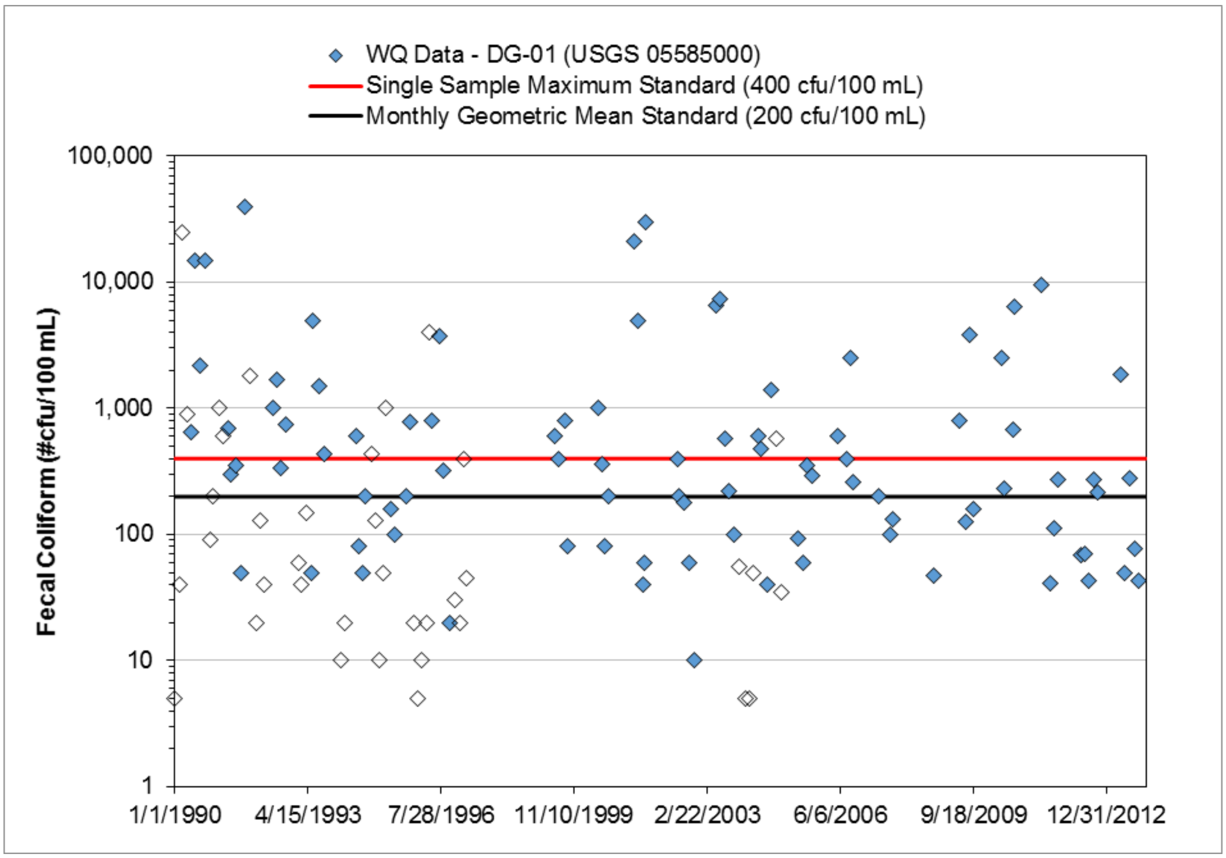

Figure 13. Fecal coliform water quality time series, La Moine River DG-01. Unfilled points indicate samples outside the standard window.

Exceedances of the single sample maximum standard occur during high and low flow conditions indicating many sources are contributing to impairment. Possible causes for high bacteria concentrations include upstream NPDES-permitted facilities, livestock, and onsite wastewater treatment systems. Two NPDES-permitted facilities discharge to tributaries of the impaired stream. Nine other facilities discharge in the upper part of the watershed, and are not likely contributing to the high fecal coliform concentrations in DG-01. In addition to NPDES-permitted facilities, livestock, and several thousand onsite wastewater treatment systems are present within the watershed. In total, there are approximately 140 animal units and 9 onsite wastewater treatment systems per square mile potentially contributing fecal coliform to the watershed. Wildlife can also be a source of fecal coliform in the watershed; approximately 27 percent of the watershed is forested, providing suitable habitat for deer and other wildlife.

5.2 Missouri Creek (DGD-01)

Missouri Creek is listed as being impaired for aquatic life due to elevated levels of manganese. One Illinois EPA sampling site was identified on Missouri Creek, DGD-02. As part of the IEPA's Intensive Basin Survey, four samples have been collected at the site, two in 2007 and two in 2012 (Table 19 and Figure 14). There were no exceedances of the standard. Three historic samples collected in 2002 at the site also do not exceed the standard, with a maximum concentration of 410 µg/L. Data do not indicate manganese impairment.

Table 19. Data summary, Missouri Creek DGD-01

Sample Site	No. of samples	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV (standard deviation/ average)	Number of exceedances of general use water quality standard
Dissolved Manganese						
DGD-02	4	58	753	1,300	0.60	0
DGD-02[a]	3	84	215	410	0.66	0

a. Data from 2002; greater than 10 years old.

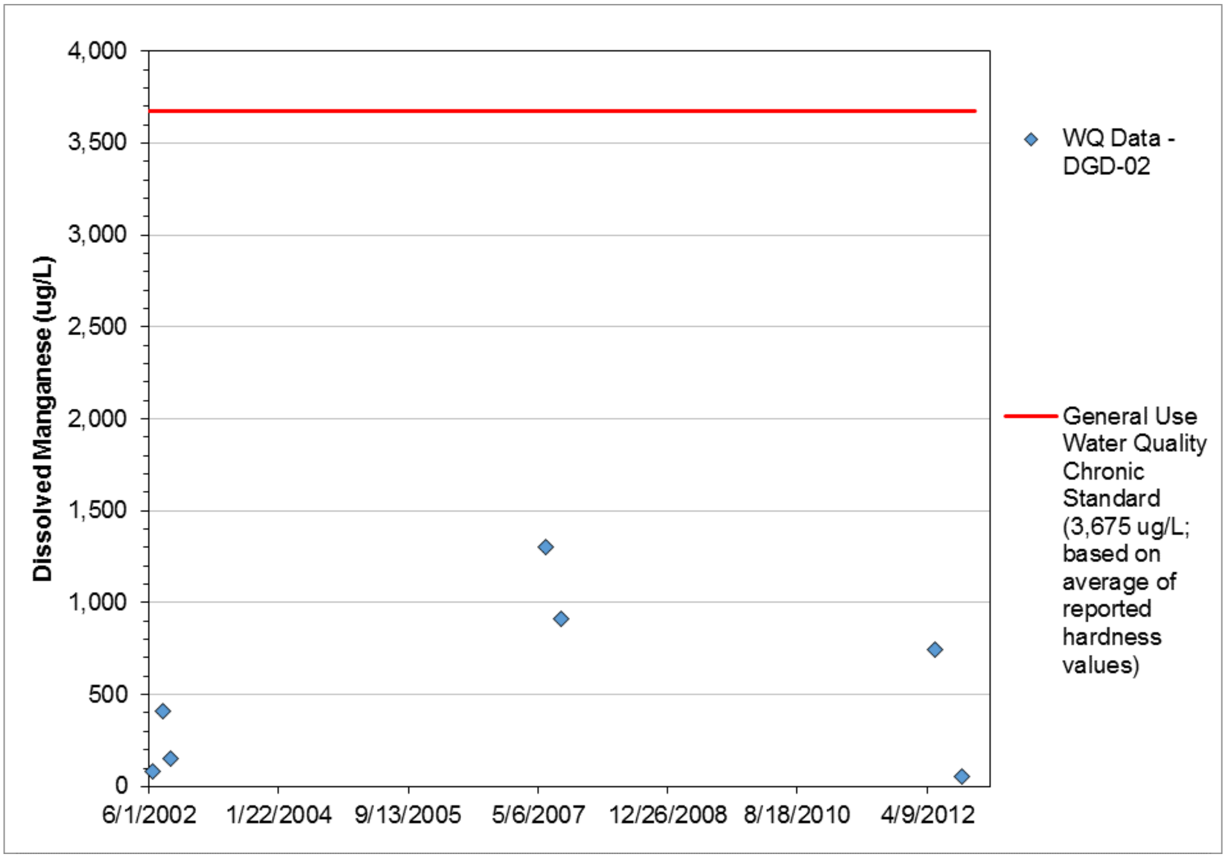

Figure 14. Dissolved manganese water quality time series, Missouri Creek DGD-01

Manganese is naturally occurring in the watershed's glacial soils which is transported to waterbodies during runoff events and through groundwater. Land use disturbances such as agricultural activities, mining, and development can increase sediment loss and associated manganese. Erosion in near channel areas that is resulting from channel downcutting and potentially altered hydrology can also contributed sediment and associated manganese to the creek. Groundwater may be high in manganese due to percolation through glacial soils. There may be other unknown sources of manganese in the watershed.

5.3 Little Missouri Creek (DGDA-01)

Little Missouri Creek is impaired for aquatic life due to elevated levels of manganese and low levels of dissolved oxygen. One Illinois EPA sampling site was identified on Little Missouri Creek, DGDA-01 (Table 20, Figure 15, and Figure 16). Two samples were collected in 2012 during May and September. There were no dissolved manganese exceedances reported. Two historical samples collected during 2002 also did not exceed the standard with a maximum value of 1,300 µg/L. Recent data do not indicate manganese impairment.

Two dissolved oxygen samples collected in 2012 (May and September) met the instantaneous minimum standards of 5 mg/L (March through July) and 3.5 mg/L (August through February). Historical data collected in 2002 include one sample collected in August 2002 is below the relevant instantaneous minimum standard. Recent data do not indicate dissolved oxygen impairment, however additional monitoring is recommended to verify impairment status and support potential de-listing.

Table 20. Data summary, Little Missouri Creek DGDA-01

Sample Site	No. of samples	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV (standard deviation/ average)	Number of exceedances of general use water quality standard
Dissolved Manganese						
DGDA-01	2	31	153	275	0.80	0
DGDA-01[a]	3	130	843	1,300	0.61	0
Sample Site	**No. of samples**	**Minimum (mg/L)**	**Average (mg/L)**	**Maximum (mg/L)**	**CV (standard deviation/ average)**	**Number of exceedances of general use water quality standard (>5 mg/L (Mar-Jul) and >3.5 mg/L (Aug-Feb))**
Dissolved Oxygen						
DGDA-01	2	6.7	7.8	8.9	0.14	0
DGDA-01[a]	3	2.6	4.4	7.2	0.45	1

a. Data from 2002; greater than 10 years old.

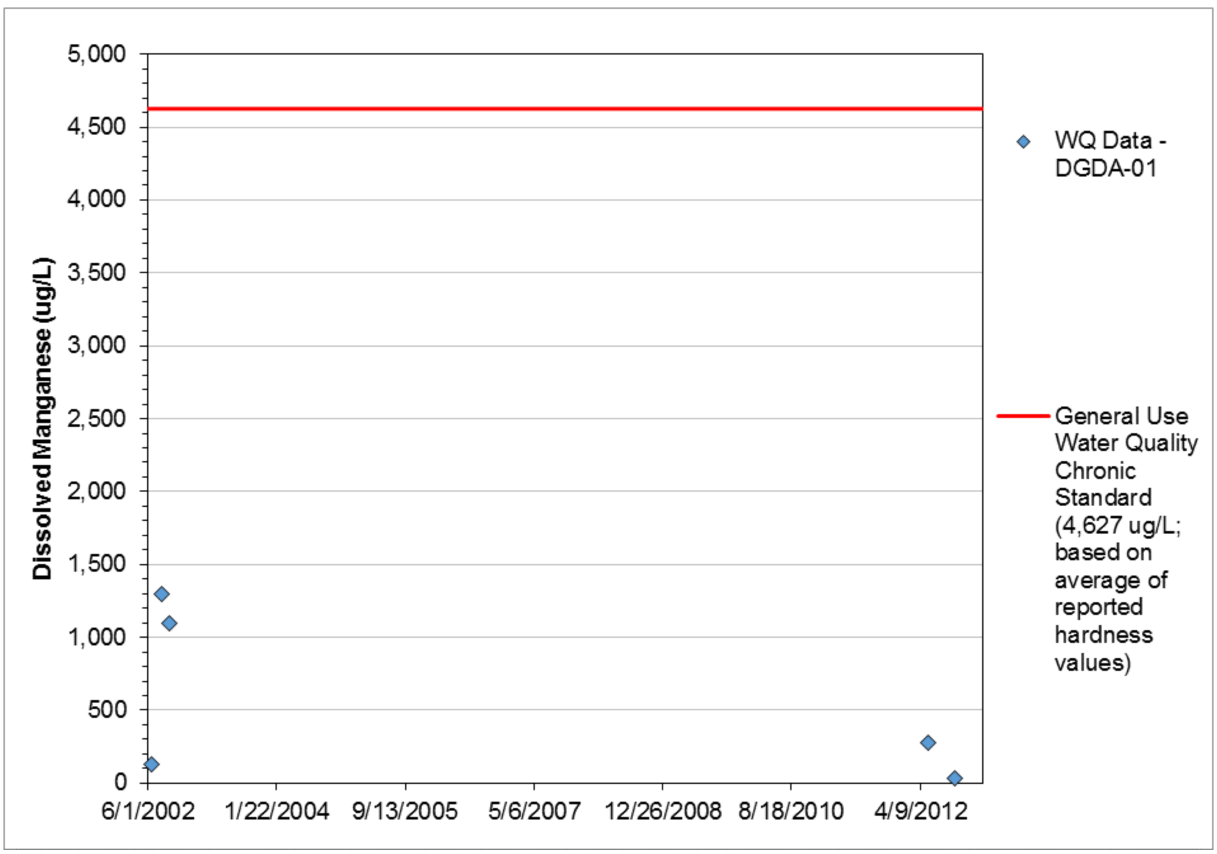

Figure 15. Dissolved manganese water quality time series, Little Missouri Creek DGDA-01.

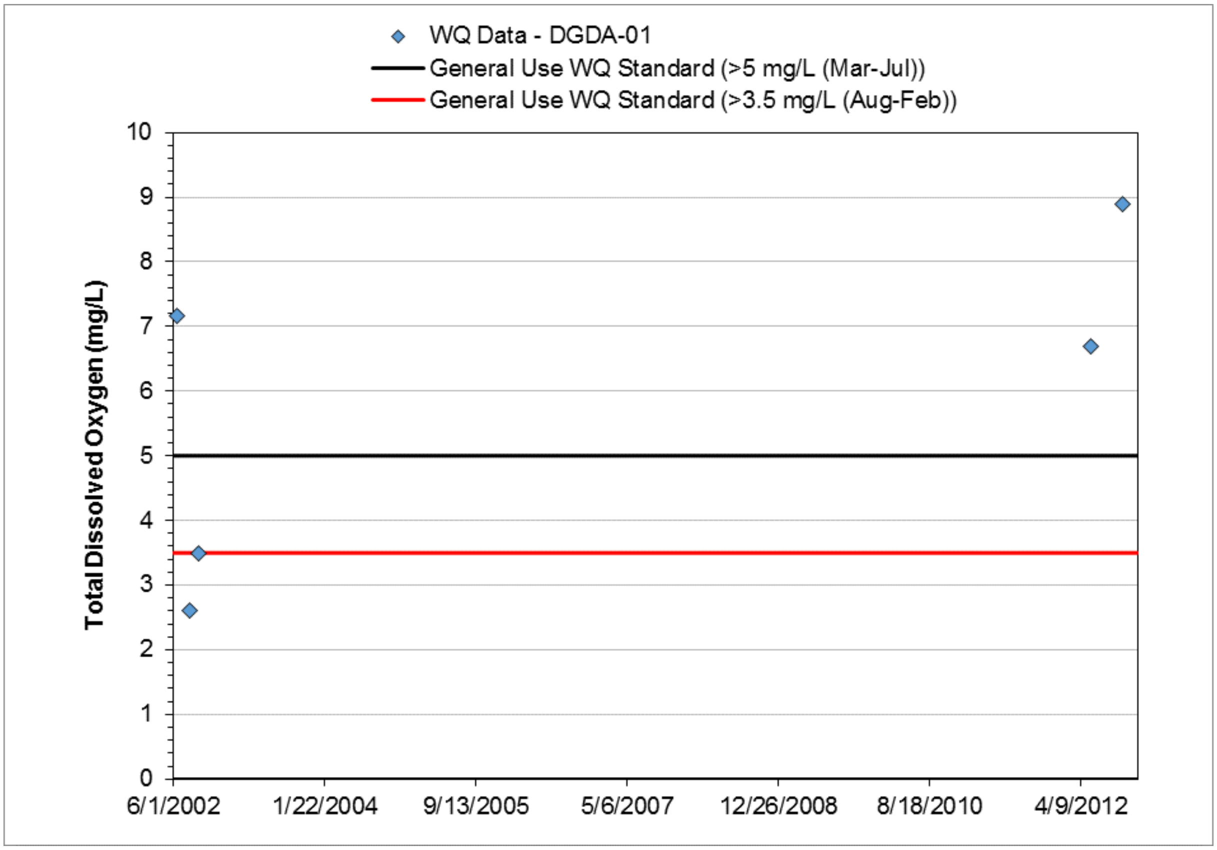

Figure 16. Dissolved oxygen water quality time series, Little Missouri Creek DGDA-01.

Manganese is naturally occurring in the watershed's glacial soils which is transported to waterbodies during runoff events and through groundwater. Land use disturbances such as agricultural activities and development can increase sediment loss and associated manganese. Erosion in near channel areas that is resulting from channel downcutting can also contributed sediment and associated manganese to the creek. In addition, within the Little Missouri Creek watershed, historical and current mining activities are potential sources. Mining activities can result in erosion, transporting sediment and associated manganese to water bodies.

Potential causes of low dissolved oxygen include altered land use in the watershed and sources of biochemical oxygen demand. In addition, in-stream conditions may also affect be affecting dissolved oxygen levels in the river. Ditching and lack of riffles and other natural structures can contribute to low dissolved oxygen levels. Agricultural land uses and livestock can also contribute to low dissolved oxygen in receiving waters. In addition, runoff from historic and active mining areas can also affect dissolved oxygen concentrations in the creek.

6. TMDL Methods and Data Needs

The first stage of this project has been an assessment of available data, followed by evaluation of their credibility. The types of data available, their quantity and quality, and their spatial and temporal coverage relative to impaired segments or watersheds drive the approaches used for TMDL model selection and analysis. Credible data are those that meet specified levels of data quality, with acceptance criteria defined by measurement quality objectives, specifically their precision, accuracy, bias, representativeness, completeness, and reliability. The following sections describe the methods that will be used to derive TMDLs and the additional data needed to develop credible TMDLs.

6.1 Stream Impairments

TMDLs are proposed for all segments with verified impairments (Table 21). Missouri Creek and Little Missouri Creek manganese data did not suggest impairment, therefore no TMDLs will be developed for manganese.

Table 21. Proposed TMDL models

Name	Segment AUID	Designated Uses	TMDL Parameters	Proposed TMDL Model
La Moine River	IL_DG-01	Primary contact recreation	Fecal Coliform	Load duration curve
La Moine River	IL_DG-04	Primary contact recreation	Fecal Coliform	Load duration curve
Missouri Creek	IL_DGD-01	Aquatic life	--	--
Little Missouri Creek	IL_DGDA-01	Aquatic life	Dissolved Oxygen	Qual2K

A duration curve approach is suggested to evaluate the relationships between hydrology and water quality and calculate the TMDLs for all stream impairments excluding the Little Missouri Creek dissolved oxygen impairment. The QUAL2K model is proposed to evaluate low dissolved oxygen in Little Missouri Creek pending impairment verification.

6.1.1 Load Duration Curve Approach

The primary benefit of duration curves in TMDL development is to provide insight regarding patterns associated with hydrology and water quality concerns. The duration curve approach is particularly applicable because water quality is often a function of stream flow. For instance, sediment concentrations typically increase with rising flows as a result of factors such as channel scour from higher velocities. Other parameters, such as chloride, may be more concentrated at low flows and more diluted by increased water volumes at higher flows. The use of duration curves in water quality assessment creates a framework that enables data to be characterized by flow conditions. The method provides a visual display of the relationship between stream flow and water quality.

Allowable pollutant loads have been determined through the use of load duration curves. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows.

2. The flow curve is translated into a load duration (or TMDL) curve by multiplying each flow value (in cubic feet per second) by the water quality standard/target for a contaminant (mg/L or count/100 mL), then multiplying by conversion factors to yield results in the proper unit (i.e., pounds per day or count/day). The resulting points are plotted to create a load duration curve.

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or load duration curve.

4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which locations contribute loads above or below the water quality standard/target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedances at the right side of the graph occur during low flow conditions, and may be derived from sources such as illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events, and may be derived from sources such as runoff. Using the load duration curve approach allows Illinois EPA to determine which implementation practices are most effective for reducing loads on the basis of flow regime. If loads are considerable during wet-weather events (including snowmelt), implementation efforts can target those best management practices that will most effectively reduce stormwater runoff.

Water quality duration curves are created using the same steps as those used for load duration curves except that concentrations, rather than loads, are plotted on the vertical axis. The stream flows displayed on water quality or load duration curves may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five hydrologic zones (U.S. EPA 2007):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 50 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The duration curve approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 22 summarizes the general relationship between the five hydrologic zones and potentially contributing source areas (the table is not specific to any individual pollutant). For example, the table indicates that impacts from point sources are usually most pronounced during dry and low flow zones because there is less water in the stream to dilute their loads. In contrast, impacts from channel bank erosion is most pronounced during high flow zones because these are the periods during which stream velocities are high enough to cause erosion to occur.

Table 22. Relationship between duration curve zones and contributing sources

Contributing source area	Duration Curve Zone				
	High	Moist	Mid-range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low).

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and U.S. EPA's implementing regulations. Because the approach establishes loads on the basis of a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions. An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions. The duration curve alone does not consider specific fate and transport mechanisms, which may vary depending on watershed or pollutant characteristics.

6.1.2 Qual2K

Qual2K is a steady-state water quality model that simulates eutrophication kinetics and conventional water quality parameters and is maintained by USEPA. QUAL2K simulates up to 15 water quality constituents in branching stream systems. A stream reach is divided into a number of computational elements, and for each computational element, a hydrologic balance in terms of stream flow (e.g., m3/s), a heat balance in terms of temperature (e.g., degrees C), and a material balance in terms of concentration (e.g., mg/l) are written. Both advective and dispersive transport processes are considered in the material balance. Mass is gained or lost from the computational element by transport processes, wastewater discharges, and withdrawals. Mass can also be gained or lost by internal processes such as release of mass from benthic sources or biological transformations.

The program simulates changes in flow conditions along the stream by computing a series of steady-state water surface profiles. The calculated stream-flow rate, velocity, cross-sectional area, and water depth serve as a basis for determining the heat and mass fluxes into and out of each computational element due to flow. Mass balance determines the concentrations of constituents at each computational element. In addition to material fluxes, major processes included in the mass balance are transformation of nutrients, algal production, benthic and carbonaceous demand, atmospheric reaeration, and the effect of these processes on the dissolved oxygen balance. The nitrogen cycle is divided into four compartments: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. The primary internal sink of dissolved oxygen in the model is biochemical oxygen demand (BOD). The major sources of dissolved oxygen are algal photosynthesis and atmospheric reaeration.

The model is applicable to dendritic streams that are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (the longitudinal axis of the stream or canal). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow and outflow.

Hydraulically, QUAL2K is limited to the simulation of time periods during which both the stream flow in river basins and input waste loads are essentially constant. QUAL2K can operate as either a steady-state or a quasi-dynamic model, making it a very helpful water quality planning tool. When operated as a steady-state model, it can be used to study the impact of waste loads (magnitude, quality, and location) on instream water quality. By operating the model dynamically, the user can study the effects of diurnal variations in meteorological data on water quality (primarily dissolved oxygen and temperature) and also can study diurnal dissolved oxygen variations due to algal growth and respiration. However, the effects of dynamic forcing functions, such as headwater flows or point loads, cannot be modeled in QUAL2K. A steady-state model is proposed for Little Missouri Creek.

QUAL2K is an appropriate choice for certain types of dissolved oxygen and organic enrichment TMDLs that can be implemented at a moderate level of effort. Use of the QUAL2K models in TMDLs is most appropriate when (1) full vertical mixing can be assumed, and (2) water quality excursions are associated with identifiable critical flow conditions. Because these models do not simulate dynamically varying flows, their use is limited to evaluating responses to one or more specific flow conditions. The selected flow condition should reflect critical conditions, which for dissolved oxygen occurs when flows are low and the ambient air temperature is warm, typically in July or August.

6.2 Additional Data Needs

Data satisfy two key objectives for Illinois EPA, enabling the agency to make informed decisions about the resource. These objectives include developing information necessary to:

- Determine if the impaired areas are meeting applicable water quality standards for their respective designated use(s); and
- Support modeling and assessment activities required to allocate pollutant loadings for all impaired areas where water quality standards are not being met.

A minimum number of data points are needed to verify impairment, typically three to five depending on the parameter. Additional data points are typically needed to understand probable sources, calculate reductions, develop validated water quality models, and develop effective implementation plans. Table 23 summarizes each segment and the need for additional data to verify impairments, potentially develop a QUAL2K model for Little Missouri Creek, or develop TMDLs.

Table 23. Additional data needs

Name	Segment ID	Designated Uses	TMDL Parameters	Needs Additional Data?
La Moine River	IL_DG-01	Primary contact recreation	Fecal coliform	Yes – 5 samples over 30-day period
La Moine River	IL_DG-04	Primary contact recreation	Fecal coliform	Yes – 5 samples over 30-day period
Missouri Creek	IL_DGD-01	Aquatic life	--	--
Little Missouri Creek	IL_DGDA-01	Aquatic life	Dissolved oxygen	Yes – to confirm impairment

Specific data needs include:

- **La Moine River (DG-01 and DG-04)** – Five fecal coliform samples collected over a 30-day period are needed to verify impairment.
- **Little Missouri Creek (DGDA-01) –**Additional dissolved oxygen sampling is also needed to verify impairment and support model development, if needed:
    - A series of grab samples should be collected in Little Missouri Creek to verify impairment; sampling should occur during the warm summer months (July-August).
    - Samples should be collected in the early morning to ensure critical conditions are captures. A lack of photosynthesis during the night will typically cause dissolved oxygen levels to be at their lowest in the early morning.
    - If impairment is verified, additional sampling will be needed to collected sufficient data to develop a QUAL2K model of the stream. This sampling could include continuous dissolved oxygen readings, flow, nutrients, temperature, channel geometry, shade/vegetation survey, channel substrate, and groundwater contributions.

7. Public Participation

<to be developed following Stage 1 meeting>

8. References

IDNR (Illinois Department of Naturel Resources). 2005. The La Moine River Basin, An Inventory of the Region's Resources. Illinois Department of Naturel Resources, Springfield, IL.

IEPA (Illinois Environmental Protection Agency). 1994. Quality Assurance Project Plan. Bureau of Water, Division of Water Pollution Control. Springfield, Illinois.

IEPA (Illinois Environmental Protection Agency). 2012. Illinois Integrated Water Quality Report and Section 303(d) List, 2012. Water Resource Assessment Information and Listing of Impaired Waters. Springfield, IL. Available online at http://www.epa.state.il.us/water/tmdl/303-appendix/2012/iwq-report-surface-water.pdf.

Illinois State Geological Survey (ISGS). 2003. Illinois Statewide 30-Meter Digital Elevation Model. Retrieved from: http://clearinghouse.isgs.illinois.edu/data/elevation/surface-elevation-30-meter-digital-elevation-model-dem.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser. 1986. Assessing Biological Integrity in Running Water: a Method and its Rationale. Illinois Natural History Survey Special Publication 5. Champaign, Illinois.

Multi-Resolution Land Characteristics Consortium (MRLC). 2015. National Land Cover Database (NLCD 2011). Retrieved from: http://www.mrlc.gov.

NESC (National Environmental Service Center). 1992 and 1998 Summary of the Status of Onsite Wastewater Treatment Systems in the US.

NRCS (Natural Resources Conservation Service). 2007. National Engineering Handbook, Part 630 Hydrology, Chapter 7 Hydrologic Soil Groups. U.S. Department of Agriculture Natural Resources Conservation Service. Available at: http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba.

Smogor, R. 2000 (draft, annotated 2006). Draft Manual for Calculating Index of Biotic Integrity Scores for Streams in Illinois. Illinois Environmental Protection Agency, Bureau of Water, Division of Water Pollution Control. Springfield, Illinois.

Smogor, R. 2005 (draft). Interpreting Illinois fish-IBI Scores. Illinois Environmental Protection Agency, Bureau of Water, Division of Water Pollution Control. Springfield, Illinois.

Tetra Tech Inc. 2004. Illinois Benthic Macroinvertebrate Collection Method Comparison and Stream Condition Index Revision, 2004.

USDA (U.S. Department of Agriculture). 2014. 2012 Census of Agriculture.

U.S. EPA (U.S. Environmental Protection Agency). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. EPA 440/4-91-001. Office of Water, Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). 2002. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047. Office of Water. Office of Science and Technology. Washington, D.C.

U.S. EPA (U.S. Environmental Protection Agency). 2007. An Approach for Using Load Duration Curves in the Development of TMDLs. EPA 841-B-07-006. U.S. Environmental Protection Agency, Washington D.C.